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THE EGGPLANT LACE-BUG.[1]

By

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(In cooperation with the Virginia truck experiment station, Norfolk, Va.)

INTRODUCTION.

Injury to eggplant by lace-bugs (Pl. I) first attracted the attention of the writer during the spring and summer of 1913. In the vicinity of Norfolk, Va., eggplant was found to be infested by a species at that time undescribed. It proved to be *Gargaphia solani* n. sp., the designation being given by Mr. Otto Heidemann, of the Bureau of Entomology. Owing to pressure of other work during the season of 1913 no further attempts were made at the time to study the insect to any great extent, but it was noted to feed extensively on eggplant, the leaves of which turn yellow and finally shrivel up. During the spring and summer of 1914 it again came under observation, investigation proving it to be widely distributed in Tidewater Virginia. In fact, wherever eggplant was grown on a commercial scale the lace-bugs were feeding. It was then considered advisable to make a careful study of the habits of this insect in view of its wide economic importance, and at the same time to devise and test methods for its control.

NATURE OF ATTACK.

In the early nymphal stages lace-bugs resemble the young of aphides; and since they procure their food by suction, the injury resulting to the plants (Pls. II, III) is indicated by a characteristic yellowing of the leaves. All stages may be found on the underside of the leaves, and in the nymphal stages, particularly, they always feed in original colonies as hatched. The first stage of injury appears in the form of circular discolored areas of about the size of a silver quarter. Such a leaf when examined will show a mass of eggs, and

[1] *Gargaphia solani* Heidemann.

NOTE.—This bulletin deals with a new enemy of eggplant and related plants. It will be of interest wherever these plants are grown commercially.

usually the female also will be observed either in close proximity feeding or in the act of ovipositing. Upon the emergence of the nymphs from the eggs the discoloration of the leaves increases in area until finally the entire leaf is involved, turning yellow and dry.

The nymphs migrate from one leaf to another, injuring every leaf attacked, until they transform, after which, as adults, they disperse to other plants. Not every plant in a field will be injured, but once a plant becomes infested every leaf may be so injured as to result in the loss of the plant.

The truckers in the vicinity of Norfolk, Va., usually raise eggplant in fields of from 6 to 10 acres. During the summer of 1914 many such fields were carefully examined, and the injury was estimated at from 10 to 15 per cent of the entire acreage. The uninformed trucker does not as yet recognize this insect as a specialized eggplant pest, since the injury closely resembles that due to aphides. As the plant-lice are feeding on the eggplant at about the same time, the lace-bug injury is usually attributed to them. The injury to eggplant by this tingitid is entirely well defined and individual in character, and no one who has carefully observed the damage would ever confuse it with that due to the work of aphides.

DESCRIPTION OF STAGES.

THE ADULT.

This interesting lace-bug belongs to the heteropterous family Tingitidæ, which contains a number of injurious forms affecting certain of our native trees and shrubs. Although many species are found in some tropical countries, those occurring in the United States are comparatively few in number.

The eggplant lace-bug is one of the larger species of the United States and differs considerably in appearance from the others by reason of its prominent lacelike hood extending back of the head and the lacelike venation of the wings. The adult (Pl. I, fig. 2) is depressed or flat bodied, grayish to light brown, about 4 millimeters ($\frac{3}{16}$ of an inch) in size, and derives its popular name from the delicate lacelike structure of the wing covers.

Following is a technical description of the adult by Mr. Otto Heidemann:[1]

> Body rather flat; dark brown; angulated; yellow rim of the rostral groove very distinct at base of metasternum. Head dark, deeply punctured; at frontal part three small slender spines, the upper one more prominent; two others near to the eyes a little longer. Antennæ quite long, hairy; basal joint comparatively thick, black, and somewhat longer than the terminal joint, which is fusciform and black at the apex; second joint the shortest, testaceous; third more than four times as long as the fourth joint, yellowish white; bucculæ moderately expanded, yellowish, with one row of minute areoles.

[1] Heidemann, Otto. A new species of North American Tingitidæ. *In* Proc. Ent. Soc. Wash., v. 16, no. 3, p. 136–137, 1 fig., Sept. 26, 1914.

Pronotum feebly convex, black, with three low yellowish carinæ, the median one a little higher before the middle, tapering toward the pale apex of the triangular posterior portion of the pronotum; the lateral membranous part of the pronotum angularly expanded, with two to five series of irregular areoles, the edge somewhat broadly reflexed, some of the nervures exteriorly blackish. Head, pronotum, and the edge of the membranous dilation densely covered with fine, soft hairs; pronotal hood rather large, much longer than wide, covering the hind part of the head, leaving the eyes free; surface yellowish white, opaque, with fine minute areoles. Hemelytra extending about one-third beyond abdomen; oblong-oval, broadly rounded at the end, feebly sinuate toward the base; the discoidal areas pyriform, reaching to about the middle of the elytra, reticulated, blackish at base and at apex, a pale stripe across the middle, the subcostal biseriate, yellow; costal margin yellowish-white, translucent with four or five series of medium-sized areoles at the widest part, those toward the base smaller; five transverse oblique nervures black at the costal area and all nervures at the apex more or less blackish. Legs pale, yellow. Length, 4 mm.; width, 2 mm.

The following descriptions of the immature stages are by the writer:

THE EGG.

Length 0.37 mm., width 0.18 mm. Color light to dark greenish at base, gradually assuming brownish toward the apex. Top of egg crater-like, with whitish lacelike border, and screwlike rim. The entire egg resembles a miniature bottle. The eggs are attached to the underside of the leaves by their bases and usually lean in all directions and at almost every angle.

THE NYMPHAL STAGES.

First stage.—Length 0.3 to 0.4 mm, width 0.12 mm. The newly hatched nymph resembles a newly born aphis, is white to light yellow, with pink eyes, long legs, and antennæ as long as body.

Second stage.—Length 0.8 mm., width 0.19 mm. Color yellow. Antennæ as long as body; the last segment clublike, covered with setæ; last segment of the legs possessing a pair of claws. There are spines on each side of the thorax and from each segment of the abdomen.

Third stage.—Length of body same as in the previous instar; width decidedly more, 0.30 mm. Spines on lateral margin and on dorsal surface of body. First indications of wing pads occur in this stage by the swelling of lateral margins of the thorax.

Fourth stage.—Length 1.5 mm., width 0.8 mm. Body oblong-ovate, yellowish. Head dark yellow, hood prominent; wing pads extending to second abdominal segment. Entire body covered with spines, the position of which is discussed in the following nymphal stage. Antennæ as long as body, light brown.

Fifth stage.—Length 2.2 mm., width 1.2 mm. (Pl. I, fig. 2.) Body oblong-ovate, yellowish except at margin of abdomen, where it is light yellow with dark patch at the apex. On the lateral margins of each side of first three abdominal segments a tubercle rises directly from the surface, and from the last six abdominal segments rise prominent spiny processes. From the middle of each of first and second abdominal segments there rise two hornlike spiny processes, and one from the fourth, fifth, and seventh segments dorsally. One spiny process and some tubercles on the lateral margin of the wing pads; two large spiny processes placed near together on the metanotum, and tubercles at each side of thorax. On each lateral margin of the hood there is a spiny process and some tubercles; two prominent spines are located centrally, and a small pair nearer the head. The head carries three strong spines in front, one long and two shorter ones; two large, strongly curved, hornlike spines at the base near the eyes. All spiny processes except on the lateral margins of the sixth, seventh, and eighth abdominal segments dark brown; those on latter light yellowish. Head yellowish brown; eyes prominent; thorax dark yellow; wing pads light yellowish with dark margin at base, extending to fifth abdominal segment. Antennæ light brown, as long as body.

DISTRIBUTION.

The collection of Tingitidæ at the U. S. National Museum contains few specimens of this species. These have been recorded by Mr. Heidemann in his paper as follows: Kirkwood, Mo., August 10 (Riley, Pergande), found on *Solanum carolinense* and *Solanum elaeagnifolium;* Lavaca County, Tex., June 21; Columbus, Tex., July 29, 1879 (Riley collection), on coffee weed (*Cassia* sp.) and *Solanum* sp.; El Reno, Okla., July 12, 1909; Norfolk, Va., June 12, 1913 and 1914 (Fink), and the author stated at the time "It is recorded as found on eggplants in great abundance." The species was also found by Dr. F. H. Chittenden, August 12, 1913, and later, and by others, including the writer, in the District of Columbia, and by the writer in Maryland and at Occoquan, Va. Judging from the localities already known it is a native American species and seems to have a range of distribution extending from the South Atlantic coast to the Southwestern States.

SEASONAL HISTORY.

THE ADULTS.

Early in spring, almost as soon as eggplants are set in the field, the hibernating adults begin to infest them and establish colonies. Thus adults and eggs were found as early as May 20. The adults reproduce and feed the entire summer on the eggplant, but migrate to the horse nettle (*Solanum carolinense*) during the latter part of August and the first week in September, when the season for eggplant is about over. Here they continue breeding until cold weather sets in. The adults hibernate in the shriveled leaves or in the ground under débris, reinfesting the next crop when set out.

The egg-laying period in the field lasts from four to five days. In the laboratory the duration is slightly longer, the temperature averaging 75° F. Table I indicates the date and number of eggs deposited by three females confined in the laboratory.

TABLE I.—*Number of eggs deposited by females of the eggplant lace-bug, Norfolk, Va., 1914.*

Female A.		Female B.		Female C.	
Date.	Number of eggs.	Date.	Number of eggs.	Date.	Number of eggs.
June 16	57	June 24	30	July 12	28
June 18	30	June 25	41	July 13	31
June 20	34	June 27	23	July 15	42
June 22	44	June 29	23	July 19	15
June 24	23				
Total	188		117		116

Females that were observed in copulation on July 12, 1914, gave the first complement of eggs July 14, 1914.

FIG. 1.—LAST NYMPHAL STAGE OF THE EGGPLANT LACE-BUG. GREATLY ENLARGED. (ORIGINAL.)

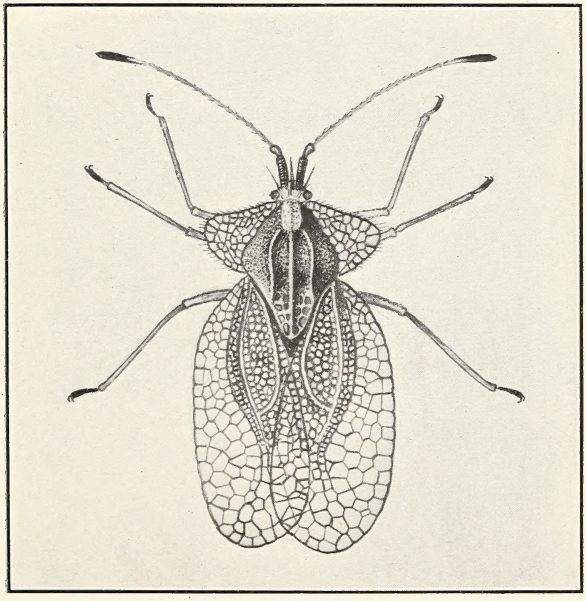
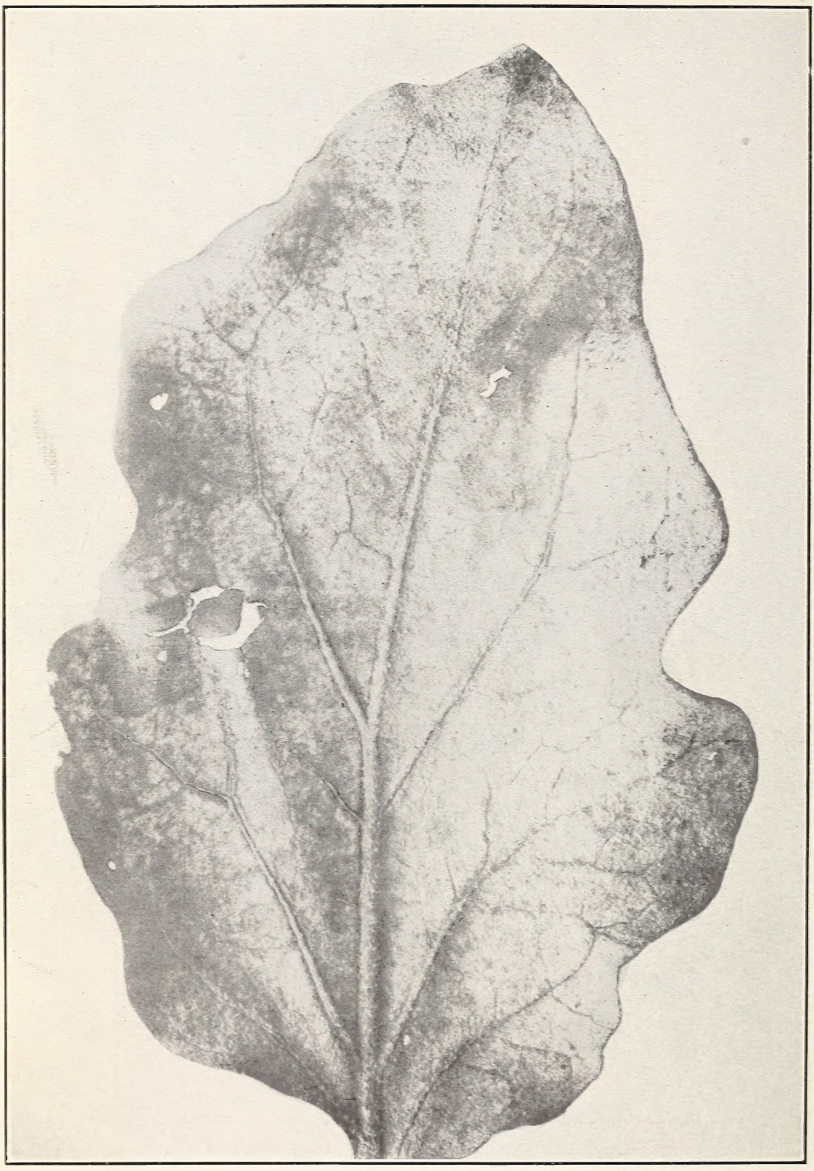


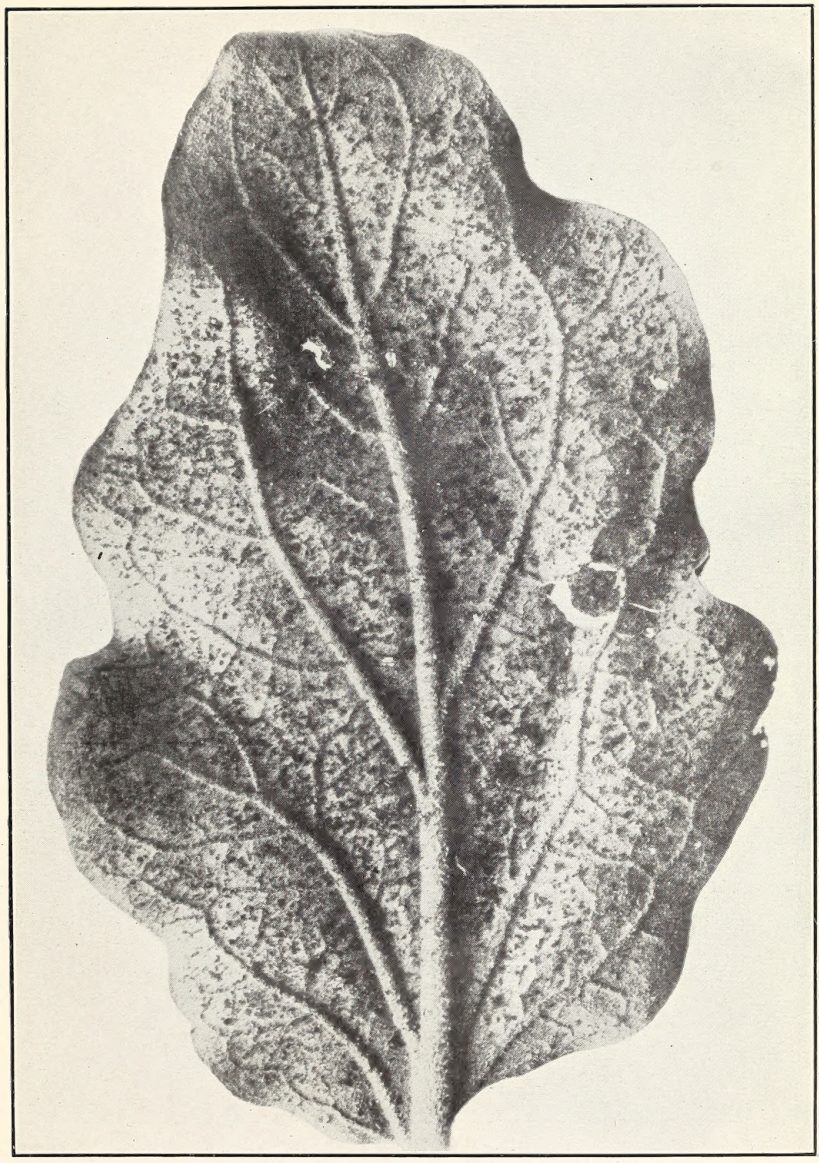
FIG. 2.—ADULT OF THE EGGPLANT LACE-BUG. GREATLY ENLARGED. (ORIGINAL.)

THE EGGPLANT LACE-BUG (GARGAPHIA SOLANI).



SURFACE OF EGGPLANT LEAF, YELLOW AND DRY AS A RESULT OF LACE-BUG ATTACK. (ORIGINAL.)

WORK OF THE EGGPLANT LACE-BUG.



UNDERSIDE OF EGGPLANT LEAF INJURED BY LACE-BUGS. (ORIGINAL.)

WORK OF THE EGGPLANT LACE-BUG.

UNDERSIDE OF LEAF OF EGGPLANT WITH ALL STAGES OF THE LACE-BUGS. (KILLED BY FISH-OIL SOAP, 7 POUNDS, TO 50 GALLONS OF WATER. NORFOLK, VA., 1914.) (ORIGINAL.)

WORK OF THE EGGPLANT LACE-BUG.

LAST NYMPHAL STAGE OF THE EGGPLANT LACE-BUG ON UNDERSIDE OF EGGPLANT LEAF. NORFOLK, VA., 1914. (ORIGINAL.)

THE EGGPLANT LACE-BUG.

SPRAYING EGGPLANTS FOR THE EGGPLANT LACE-BUG. NORFOLK, VA. (ORIGINAL.)

THE EGGPLANT LACE-BUG.

THE EGGS.

The minute greenish eggs are deposited on the underside of the leaves in circular masses of about 116 to 188. Their bases are attached in irregular rows, not erect, but, as before stated, leaning in different directions and at different angles. A sticky secretion is spread over the eggs after oviposition. To the unaided eye the eggs appear like a mass of mere dots on the underside of the leaf, occupying an area of leaf surface about one-half inch in diameter. The female attends the eggs during the entire period of incubation, leaving them only at intervals to feed, and later, when the nymphs emerge, is constantly in attendance.

Table II indicates the normal period of incubation for the summer months. Since not all the eggs are deposited at one time by the female, the emergence of the nymphs extends over several days. The table, however, refers to dates when nymphs first began emerging.

TABLE II.—*Incubation period of the eggplant lace-bug, Norfolk, Va., 1914.*

No.	Date of deposition of eggs.	Date of emergence of nymphs.	Incubation period.	No.	Date of deposition of eggs.	Date of emergence of nymphs.	Incubation period.
			Days.				*Days.*
1	May 24	May 30	6	6	June 23	June 28	5
2	May 25	May 31	6	7	June 23	June 29	6
3	June 15	June 23	8	8	June 26	July 3	7
4	June 17	June 24	7	9	July 4	July 19	5
5	June 21	June 26	5				

THE NYMPHS.

The nymphs are always found feeding in groups (Pls. IV and V). After the first molt they become yellow and at the same time shift their feeding position on the leaves. When migrating from one leaf to another the female adult usually directs the way, and with her long antennæ keeps the nymphs together or rebukes any straggler or deserter. It is an interesting sight to observe the migration of a colony of more than a hundred nymphs, with the female adult hurrying from one end of the flock to the other, keeping them together, and at the same time urging them in the right direction during the migration. When a new area has been selected the nymphs settle down, insert the proboscis, and begin to feed.

In its undeveloped forms, particularly in its last two nymphal stages, the eggplant lace-bug is an interesting and grotesque-looking object. The head and body are covered with spiny processes the function of which is not yet well understood. Some of the spines on the head are hornlike and, situated as they are near the eyes, they resemble very much the horns of some domesticated animals.

That the adult female keeps a watchful eye for intruders and enemies while in attendance on the nymphs is attested by the following

observation: On one occasion while observing the feeding of the nymphs a ladybeetle (*Hippodamia convergens* Guer.) was seen to approach the brood, when the adult lace-bug in attendance on the nymphs, with outstretched, slightly raised wings, suddenly darted toward the intruder, driving it from the leaf.

From the time the nymphs are born until they reach the adult form they pass through five distinct molting periods, and when temperature and other conditions are normal the time between molts is quite constant. From Table III it will be observed that two days is the usual period between molts.

TABLE III.—*Molting stages of nymphs of the eggplant lace-bug, Norfolk, Va., 1914.*

No.	Date hatched.	First molt.	Second molt.	Third molt.	Fourth molt.	Fifth molt.	Adult.
1	.....	July 9	July 11	July 13	July 15	July 17	
2	.....	...do.....	...do.....	...do.....	...do.....	...do.....	
3	.....	...do.....	...do.....	...do.....	...do.....	...do.....	
4	.....	July 10	July 12	July 15	July 17	July 18	
5	July 7	July 9	July 11	July 13	July 15	...do.....	Adult.
6	.....	...do.....	...do.....	...do.....	...do.....	July 17	
7	.....	...do.....	...do.....	...do.....	...do.....	...do.....	
8	.....	...do.....	...do.....	...do.....	Dead.	...do.....	
9	.....	...do.....	...do.....	...do.....	July 15	...do.....	

LIFE CYCLE AND NUMBER OF GENERATIONS.

Since two days represents the duration of time between molts, the life of the nymph from the egg to the last nymph, under normal conditions, is 10 days. Allowing six days for the egg stage and several days for time before and after copulation by adults, the life cycle is approximately 20 days.

In the vicinity of Norfolk, Va., this lace-bug was found breeding as late as November, giving a breeding season of nearly six months. There is a possibility of from seven to eight generations a season. Apparently six generations are spent on eggplant and the remainder on horse nettle.

Most of the generations in the field overlap, and the following observations made during the summer of 1914 indicate that six generations are spent on eggplant.

First generation, May 24.
Second generation, June 11.
Third generation, July 7.
Fourth generation, July 26.
Fifth generation, August 15.
Sixth generation, September 4.

In the region of Norfolk, Va., as stated before, the growing season for eggplant ends about the last of August or the first week in September, after which the lace-bug is found on the horse nettle (*Solanum carolinense*), where it continues to feed. It undoubtedly produces several generations on this plant, for as late as November all stages of the insect, including eggs, were found on it.

NATURAL ENEMIES.

Several predaceous insects were observed feeding on the nymphs and adults of the eggplant lace-bug. The species of ladybeetles common in this section, *Hippodamia convergens* Guer. and *Megilla maculata* De Geer, in both the larval and adult forms feed on the nymphs and adults of this lace-bug, usually turning them over on their backs before feeding. A common soldier-bug, *Podisus maculiventris* Say, feeds on the nymphs. Another common hemipteron found feeding on the nymphs is *Triphleps insidiosus* Say. Three species of spiders, *Epeira domiciliorum* Hentz, *Plectana stellata* Hentz, and *Chiracanthium inclusum* Hentz, identified by Mr. Nathan Banks, of the Bureau of Entomology, were observed feeding on all stages of the lace-bugs. It was not uncommon to find many lace-bugs with the head severed and the body mutilated. A very few specimens of a hymenopterous parasite were reared with the adult lace-bugs; this was identified as *Microdus* sp.[1] but it was not positively proved to attack the lace-bug.

METHODS OF CONTROL.

June 17 and 18, 1914, a series of spraying experiments against this lace-bug was undertaken in which the comparative values of fish-oil soap and various strengths of a standard blackleaf tobacco extract containing 40 per cent active nicotine sulphate were tested. (See Plate IV.) The results were quite satisfactory.

TABLE IV.—*Spraying experiments against the eggplant lace-bug, Norfolk, Va., 1914.*

No.	Fish-oil soap.	Nicotine sulphate.	Nymphs killed (per cent).	Adults killed (per cent).
1	1 pound to 50 gallons of water	1 to 1,066	80 to 85	None.
2	do	1 to 800	90	None.
3	do	1 to 640	85 to 90	None.
4	2½ pounds to 50 gallons of water		80 to 85	None.
5	3 pounds to 50 gallons of water		90	None.
6	5 pounds to 50 gallons of water		95	None.
7	6 pounds to 50 gallons of water		100	40 to 50
8	7 pounds to 50 gallons of water		100	90 to 95
9	8 pounds to 50 gallons of water		100	95

From the above table it will be readily seen that the percentage of nymphs killed was but slightly affected by the increase in the amount of the nicotine sulphate, and that the latter had no effect whatever on the adults; whereas with each increase in the amount of fish-oil soap there was a corresponding increase in the percentage of nymphs killed, until finally we arrive at a strength which will affect the adults. Above that strength we may then get perfect control of both the nymphs and adults.

Too much emphasis can not be laid on the thoroughness with which the spraying should be performed. It is particularly essential that the underside of the leaves be thoroughly covered by the spray.

[1] Chttn. No. 1373[01].

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